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(54) **ORTHOPEDIC STRUT WITH LOCKABLE SWIVEL HINGES**

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**A61B 17/66** (2006.01)  
**A61B 17/62** (2006.01)  
**A61B 17/00** (2006.01)

(52) **U.S. Cl.**  
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(58) **Field of Classification Search**  
CPC ..... A61B 17/62; A61B 17/64; A61B 17/6425; A61B 17/6416; A61B 17/645; A61B 17/6475  
See application file for complete search history.

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(57) **ABSTRACT**  
Provided are a telescoping, adjustable orthopedic strut for use in conjunction with an external bone fixation (EBF) device and an EBF device that employs the strut. The strut includes swivel hinges at each end, wherein each swivel hinge is lockable in any position within a one hundred eighty degree (180°) plane and has a three hundred sixty degree (360°) angle of rotation with respect to an orthopedic plate of the EBF device; an outer sleeve; an inner sleeve configured to slide within the outer sleeve; wherein the inner sleeve and outer sleeve may be positioned and fixed with respect to each other to provide an acute adjustment of the length of the strut; a leadscrew threaded into the inner sleeve, wherein the lead screw can be either rotated or fixed in position to provide a fine adjustment of the length of the strut.

**11 Claims, 7 Drawing Sheets**

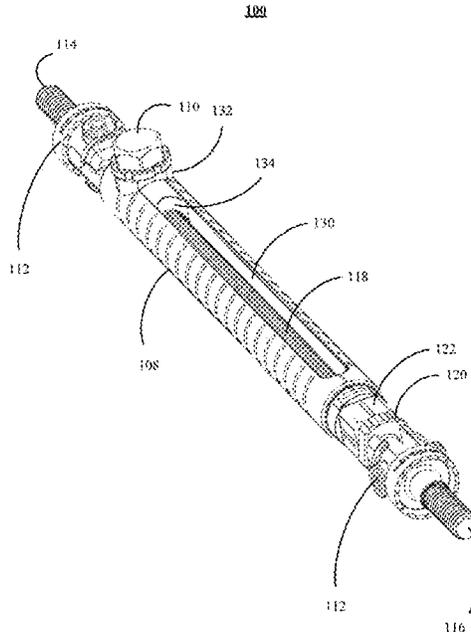


Figure 1

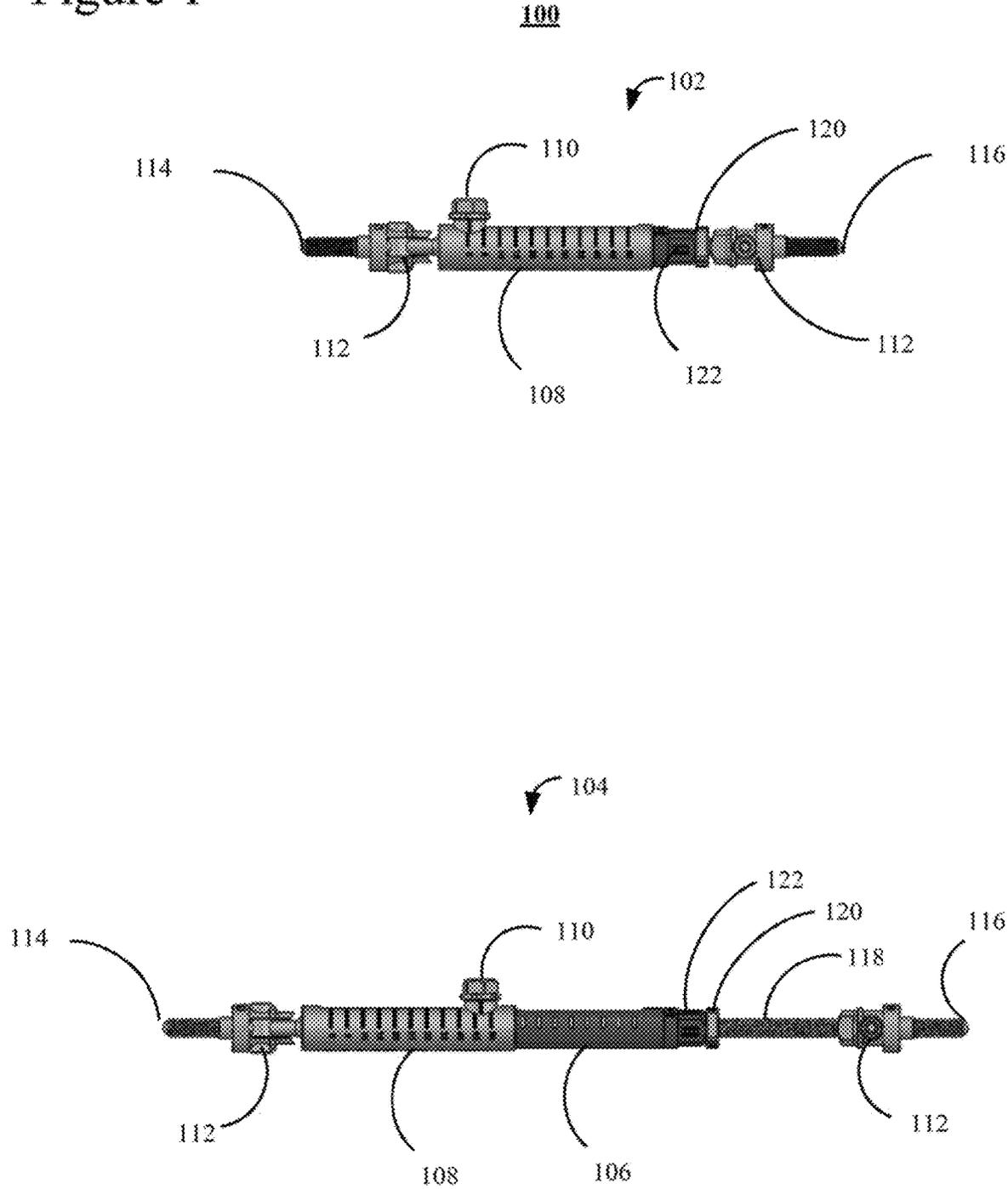


Figure 2

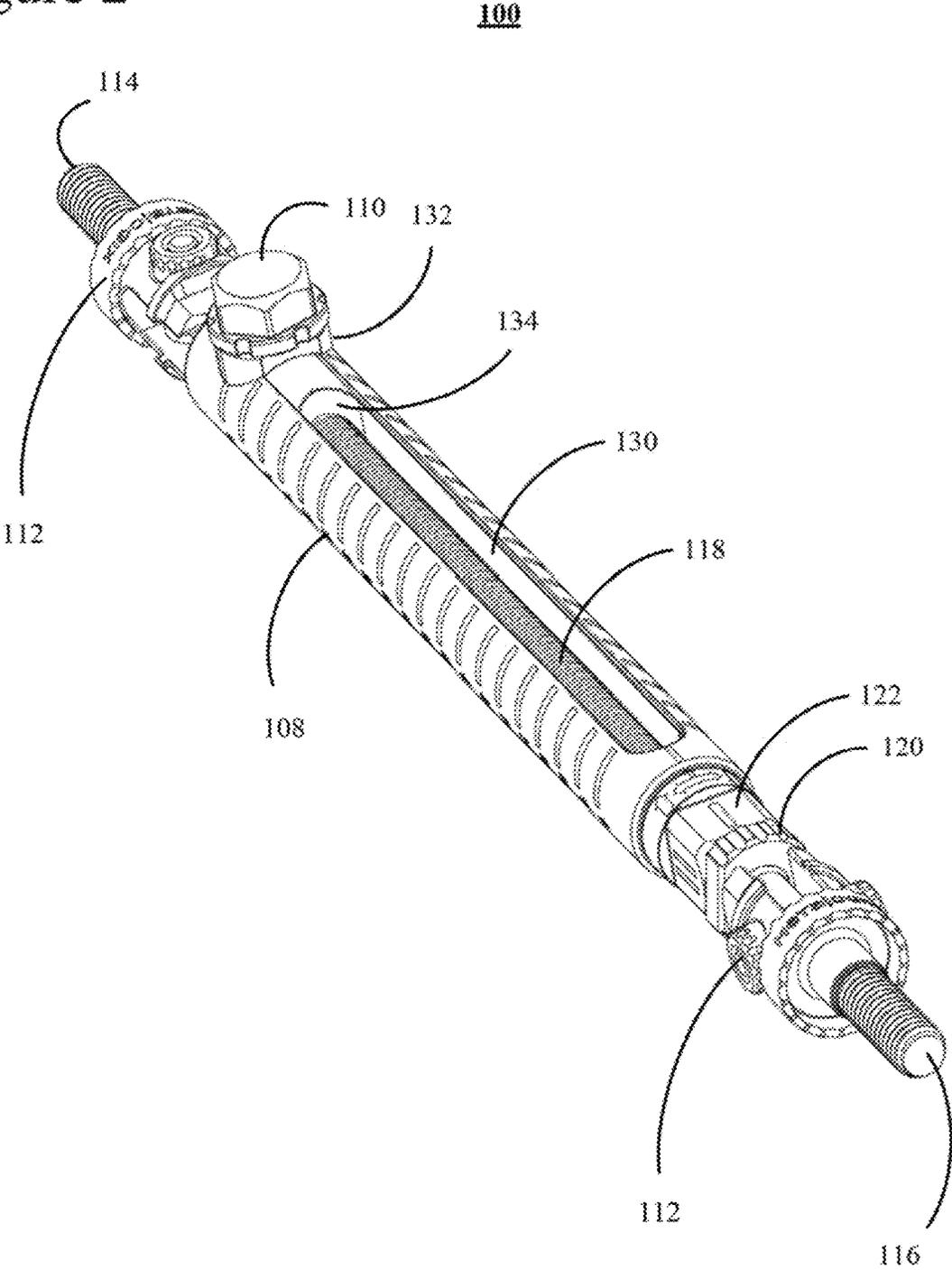


Figure 3

100

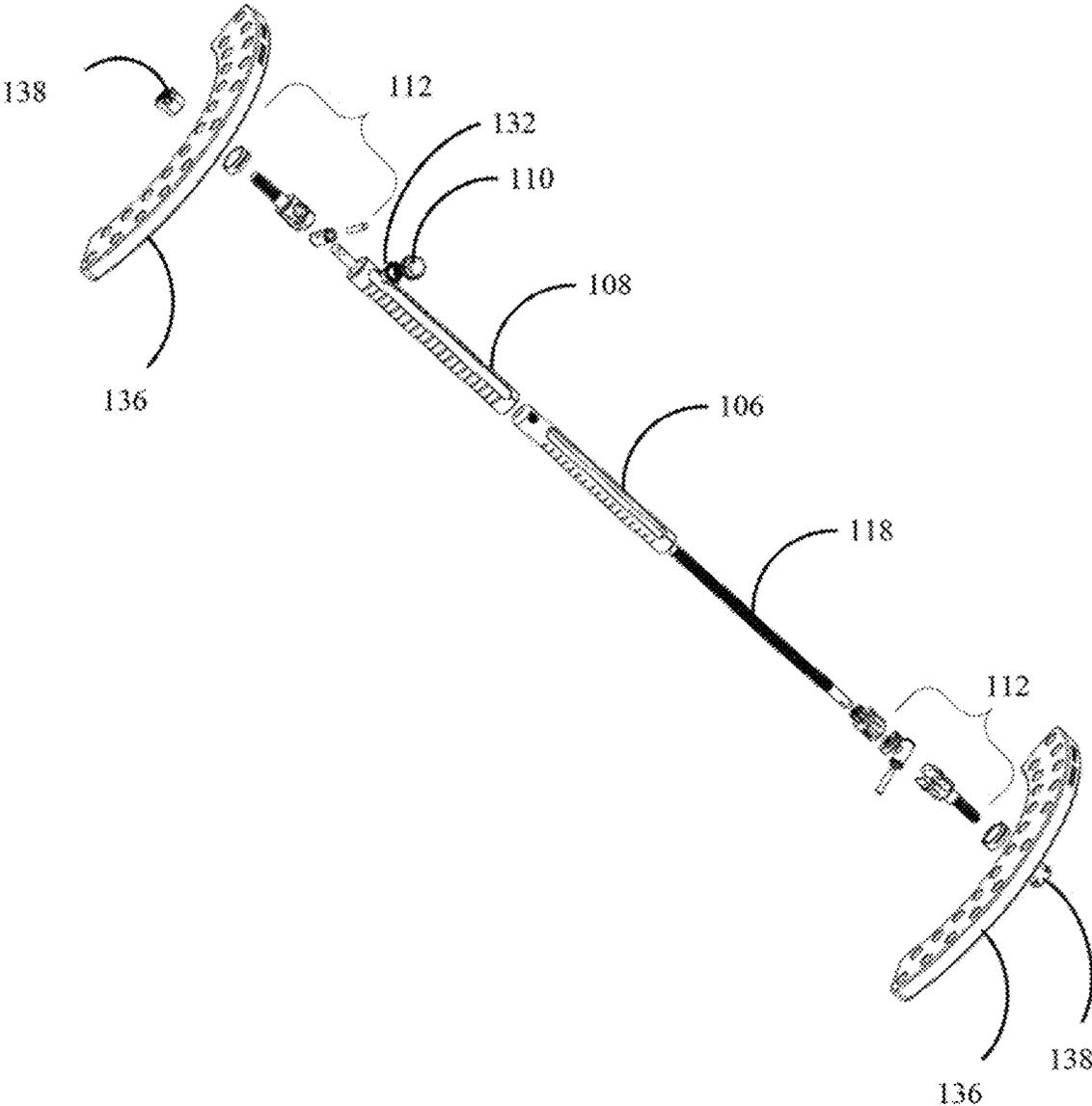


Figure 4

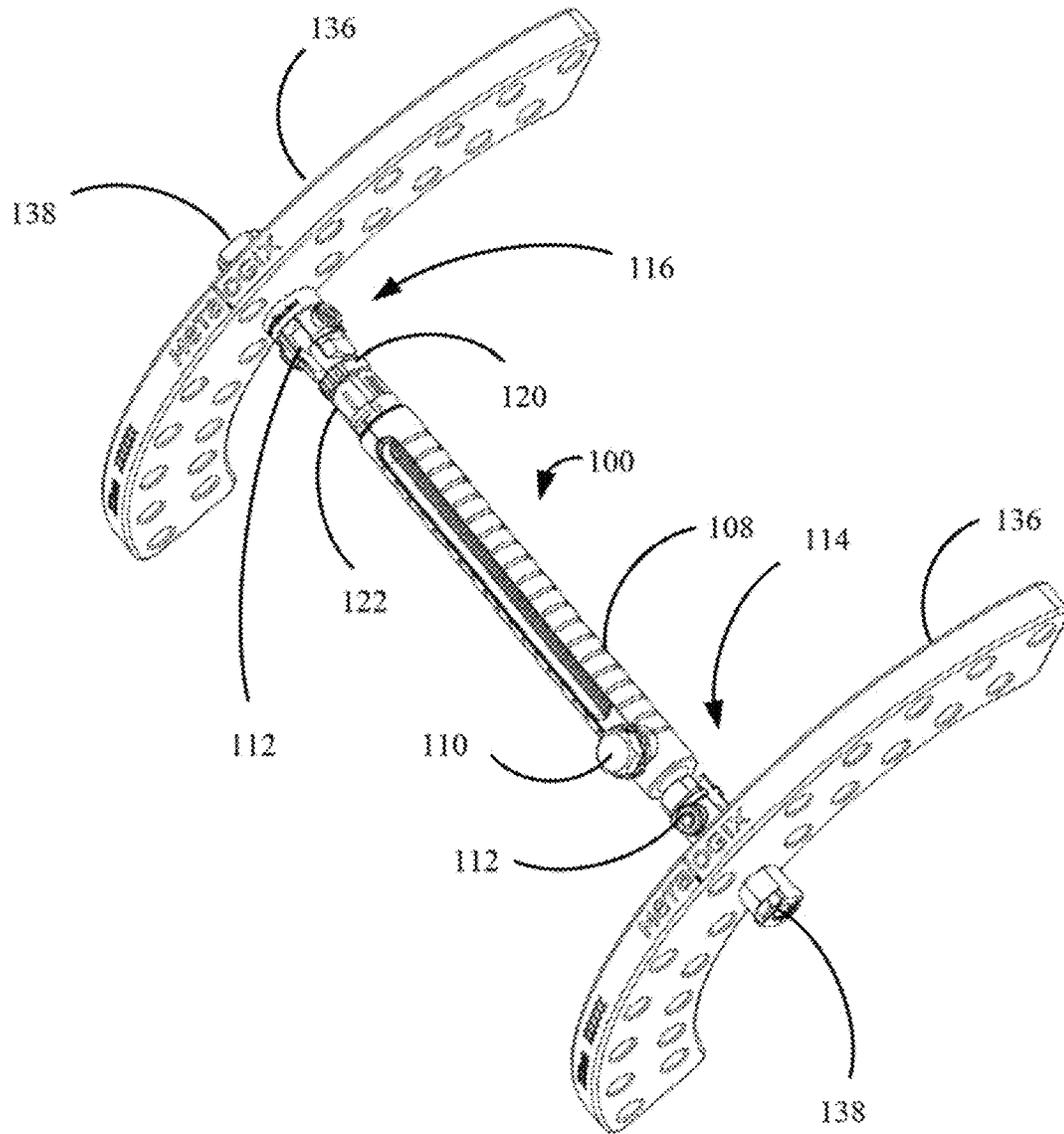


Figure 5

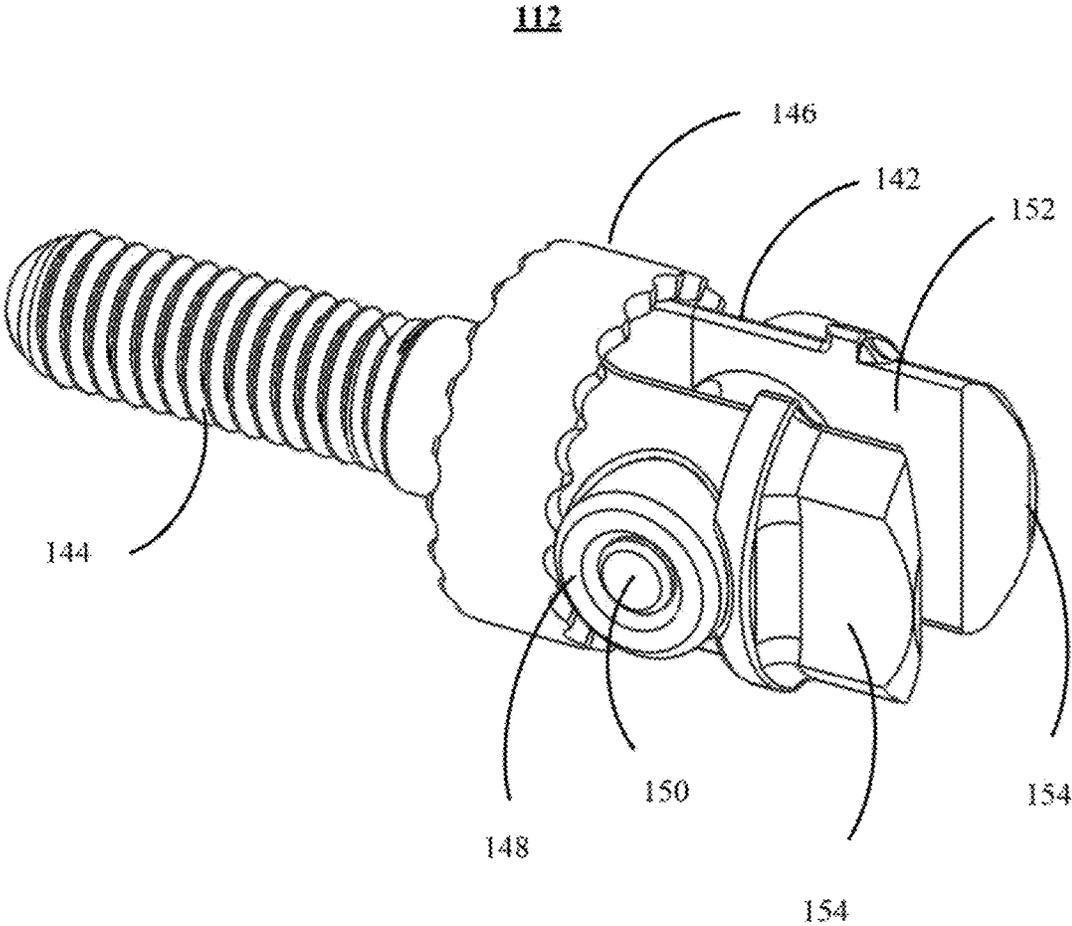


Figure 6

112

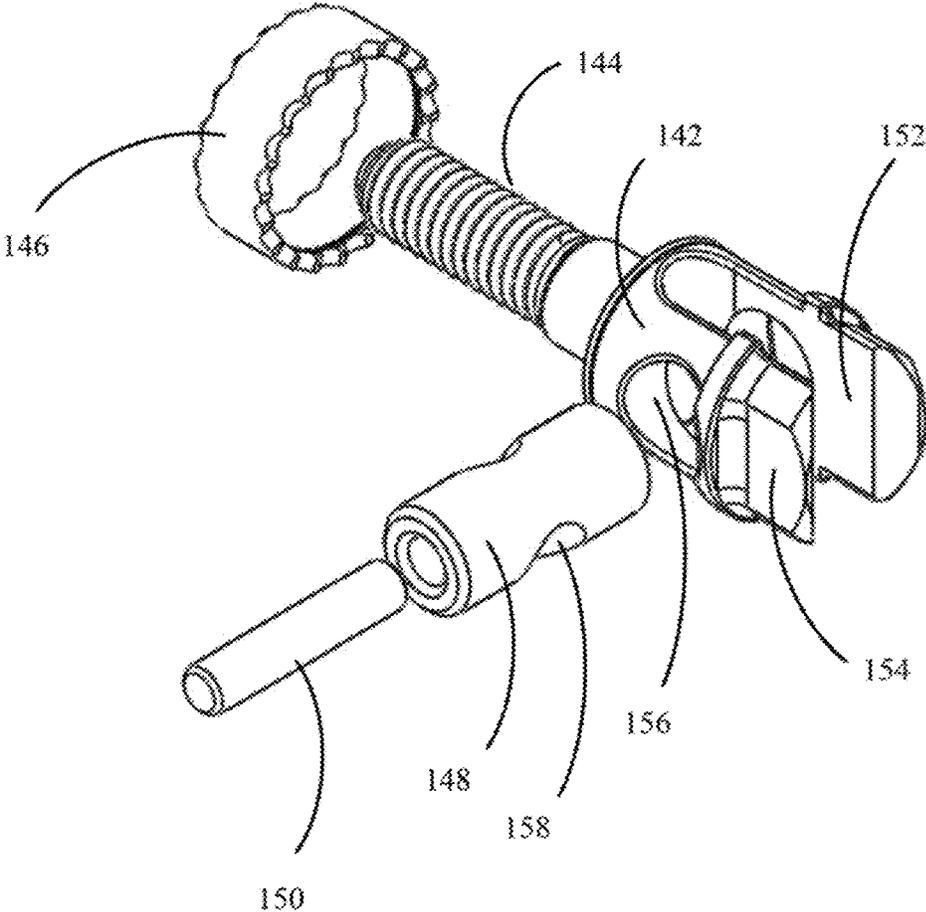
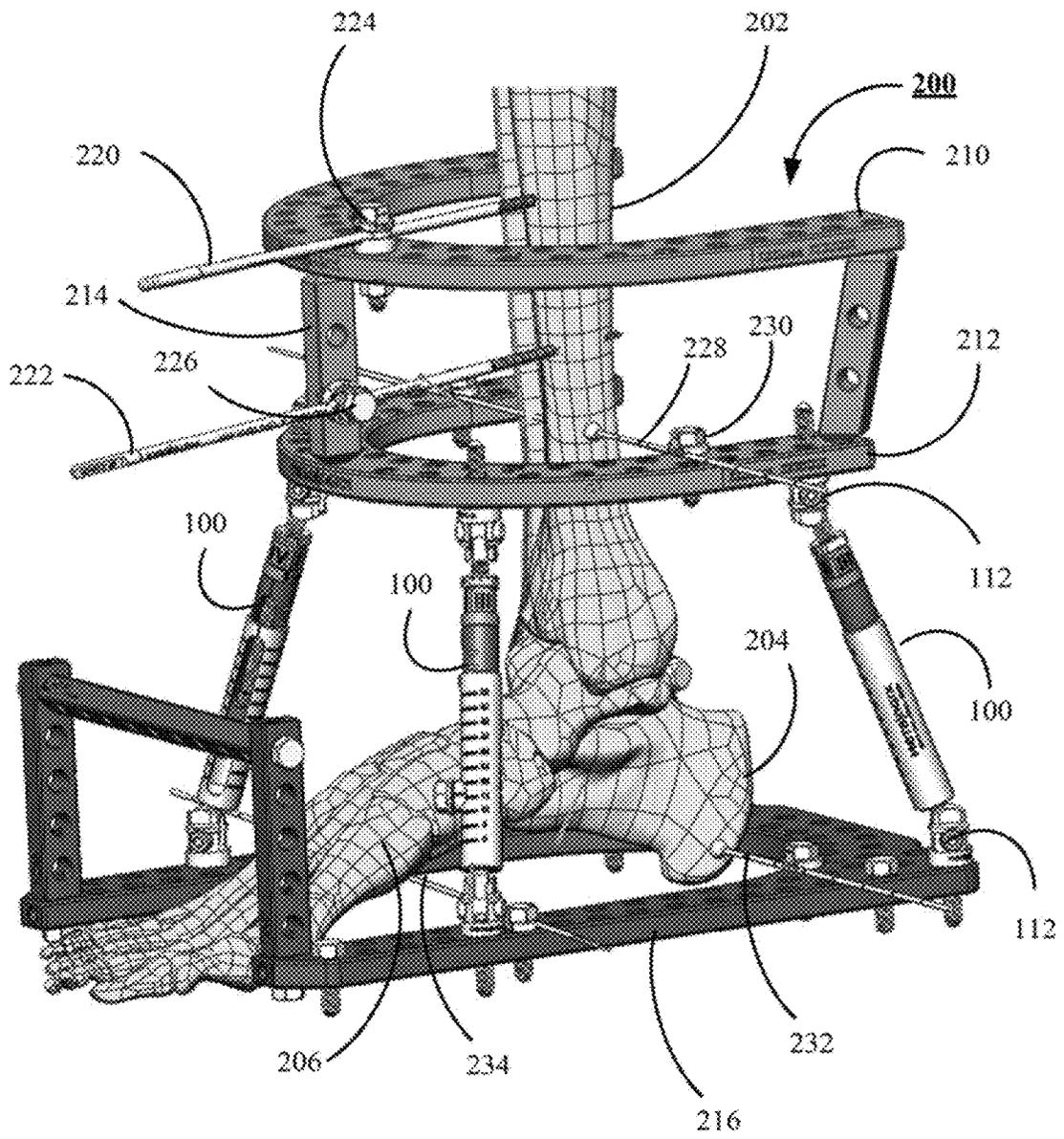


Figure 7



## ORTHOPEDIC STRUT WITH LOCKABLE SWIVEL HINGES

### FIELD OF THE DISCLOSURE

The claimed subject matter relates generally to an orthopedic strut with lockable swivel hinges and, more specifically, a telescoping adjustable strut with versatile hinge structures for use with an external bone fixation device.

### BACKGROUND

External Bone Fixation (EBF) devices are employed in the treatment of bone deformity and acute trauma. Typical EBF devices use circular rings that surround a patient's limb. Adjustable connection rods and struts are employed to connect the circular rings together. Current connection rods have only a conical range of seven degrees (7°) and struts have only forty-seven degrees (47°), which reduces the functionality of the rods and struts, limiting the ability to connect circular rings together. Half pins and wires are employed to attach the circular rings to a patient's bone to stabilize the bone while the bone or bones are being corrected or healing. The half pins and wires attach to the EBF device at one or two points and are either drilled into or through a bone.

One well-known reconstructive EBF system is the Ilizarov frame, as shown in U.S. Pat. Nos. 4,365,624; 4,615,338; 4,978,348; 5,702,389 and 5,971,984. The Ilizarov frame uses a combination of circular frames, pins and wires for deformity correction.

### SUMMARY

Provided are telescoping, adjustable struts for connecting plates employed in orthopedic external bone fixation (EBF) devices. The telescoping, adjustable struts incorporate lockable swivel hinges. The swivel hinges provide one hundred eighty degrees (180°) of movement in one direction and three hundred sixty degrees (360°) of rotation in another direction. A lockable swivel hinge is typically positioned on each end of a telescoping, adjustable strut. EBF devices, which employ the telescoping, adjustable struts, are used to fix broken bones and to stabilize bones that are being corrected or healing.

Provided are a telescoping, adjustable orthopedic strut for use in conjunction with an external bone fixation (EBF) device and an EBF device that employs the strut. The strut includes a plurality of swivel hinges, wherein each swivel hinge is lockable in any position within a one hundred eighty degree (180°) plane and a three hundred sixty degree (360°) angle of rotation with respect to an orthopedic plate of the EBF device; an outer sleeve; an inner sleeve configured to slide within the outer sleeve; wherein the inner sleeve and outer sleeve may be positioned with respect to each other and, when a fixation bolt is tightened, the inner sleeve and outer sleeve are secured with respect to each other to provide an acute adjustment; a leadscrew threaded into the inner sleeve; a jam nut threaded onto the leadscrew such that, when a jam nut is not tighten against a compression/distract (C/D) nut, the leadscrew is free to rotate with respect to the C/D nut and inner sleeve and, when the jam nut is tightened against the C/D nut, the leadscrew is fixed, thereby providing a fine adjustment to an overall length of the strut; and a second swivel hinge of the plurality of swivel hinges coupled to an end of the leadscrew.

This summary is not intended as a comprehensive description of the claimed subject matter but, rather, is intended to provide a brief overview of some of the functionality associated therewith. Other systems, methods, functionality, features and advantages of the claimed subject matter will be or will become apparent to one with skill in the art upon examination of the following figures and detailed description.

### BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the claimed subject matter can be obtained when the following detailed description of the disclosed embodiments is considered in conjunction with the following figures.

FIG. 1 is an illustration of two configurations of a telescoping, adjustable strut with lockable swivel hinges manufactured in accordance with the claimed subject matter.

FIG. 2 is an illustration of the telescoping, adjustable strut, introduced in FIG. 1, from a perspective that shows additional details.

FIG. 3 is an illustration of the telescoping, adjustable strut, shown in FIGS. 1 and 2, disassembled to show individual components more clearly.

FIG. 4 is an illustration of the telescoping, adjustable strut, described in conjunction with FIGS. 1-3, connecting two orthopedic plates.

FIG. 5 is an illustration of a lockable swivel hinge, first introduced in FIG. 1, in greater detail.

FIG. 6 is an illustration of the lockable swivel hinge of FIGS. 1-5 disassembled to more clearly show the component parts.

FIG. 7 is an illustration of an illustration of an External Bone Fixation (EBF) device, attached to a patient's foot and leg bones, that employs the telescoping, adjustable strut shown in FIGS. 1-4 and the lockable swivel hinge shown in FIGS. 1-6.

### DETAILED DESCRIPTION OF THE FIGURES

The illustrations and diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems according to various embodiments of the present invention.

Turning now to the figures, FIG. 1 is an illustration of two configurations of a telescoping, adjustable strut **100** with lockable swivel hinges manufactured in accordance with the claimed subject matter. A first configuration **102** shows strut **100** in a collapsed, or shortened position. A second configuration **104** shows strut **100** in an extended position. It should be understood that strut **100** may be configured, in addition to configurations **102** and **104**, in any position in between shortened and extended positions **102** and **104**.

An inner sleeve, or tube, **106**, which is not visible in configuration **102**, fits into an outer sleeve, or tube, **108**. A fixation bolt **110**, which is explained in more detail below in conjunction with FIG. 2, prevents inner sleeve **106** from moving with respect to outer sleeve **108** when bolt **110** is tightened. In this manner, the length of strut **100** may be easily be adjusted anywhere between the collapsed and extended positions **102** and **104**. This adjustment of the length of strut **100** is called "acute" adjustment. At each end of strut **100** is a lockable swivel hinge **112** that is lockable in a one hundred eighty degrees (180°) and rotatable in three hundred sixty degrees (360°) when inserted into an orthopedic plate (see **136**, FIGS. **3** and **4** and **212** and **216**, FIG.

7). Lockable swivel hinge **112** is described in more detail below in conjunction with FIGS. **5** and **6**.

For the sake of reference, the end of strut **100** on outer sleeve **108** side is labeled as a “stationary” end **114** and the end on inner sleeve **106** side as “moving” end **116**. The terms “stationary” and “moving” are used because stationary end **114** doesn’t rotate relative to outer sleeve or move in or out relative to outer sleeve **108** during adjustment of the length of strut **100**. Moving end **116** is able to rotate three hundred sixty degrees (360°) by virtue of the fact that a leadscrew **118** may be rotated.

Visible in configuration **104**, threaded rod, or “lead-screw,” **118** threads into a jam nut **120** and a compression/distraction (C/D) nut **122**. C/D nut **122** is pressed into and thereby attached to inner sleeve **106** such that C/D nut **122** is free rotate three hundred and sixty degrees (360°) with respect to inner sleeve **106**. A care provider may accurately control the length of strut **100** by loosening jam nut **120**, turning C/D **122** either clockwise or counterclockwise with respect to inner sleeve **106**, thereby screwing leadscrew **118** either further into or out of inner sleeve **106**, and tightening jam nut **120** against C/D nut **122** to both prevent leadscrew **118** from rotating and to lock the overall length of strut **100**. This adjustment of the length of strut **100** is called “micro” or “fine” adjustment. Leadscrew **118**, nut **120** and CD nut **122** provide a finer adjustment of the length of strut **100** than that provided by the acute adjustment of the relative positions of inner sleeve **106** and outer sleeve **108** as described above.

FIG. **2** is an illustration of strut **100**, introduced in FIG. **1**, from a perspective that shows additional details. Like FIG. **1**, FIG. **2** shows outer sleeve **108**, fixation bolt **110**, swivel hinges **112**, stationary end **114** and moving end **116**. FIG. **2** shows strut **100** from an angle that shows an opening, or groove, **130** in outer sleeve **108** (FIG. **1**) through which fixation bolt **110** is positioned. Fixation bolt **110** passes through opening **130**, a clamping washer **132** and is treaded into inner sleeve **106** (FIG. **1**), only a portion **134** of which is visible in FIG. **2**. Washer **132** is configured to be flat on one side and conform to the curvature of outer sleeve **108** on a second side. When fixation bolt **110** is loosened, inner sleeve **106** and outer sleeve **108** may be easily moved with respect to each other. When fixation bolt **110** is tightened, outer sleeve **108** is compressed between washer **132** and inner sleeve **106**, thereby preventing inner sleeve **106** and outer sleeve **108** from moving with respect to each other thereby providing an acute adjustment of strut **100**.

Also illustrated in FIG. **2** is leadscrew **118** (FIG. **1**) which is threaded into C/D nut **122**, which is pressed fitted into inner tube **106**, and jam nut **120**. Leadscrew **118** is coupled to swivel hinge **112** that terminates at moving end **116** (FIG. **1**). As explained above in conjunction with FIG. **1**, a care provider may make a micro adjustment of strut **100** by loosening jam nut **120**, turning C/D nut **122** and then tightening jam nut **120** against C/D nut **122**.

FIG. **3** is an illustration of strut **100**, shown in FIGS. **1** and **2**, disassembled to show individual components more clearly. Also illustrated are two (2) orthopedic plates **136** that might be connected with strut **100** as part of a part of an External Bone Fixation (EBF) device (see **200**, FIG. **7**). Like FIG. **2**, FIG. **3** shows inner sleeve **106**, outer sleeve **108**, fixation bolt **110**, clamping washer **132**, leadscrew **118** and swivel hinges **112**, which in this view are also disassembled (see FIG. **5**). Also shown are two (2) speed nuts **138** that are employed to attach swivel hinges **112** to orthopedic plates **136**.

FIG. **4** is an illustration of strut **100**, described in conjunction with FIG. **1-3**, connecting orthopedic plates **136** (FIG. **3**). In this figure, strut **100** is configured in shortened configuration, or position, **102** (FIG. **1**). Strut **100** is secured to orthopedic plates **136** (FIG. **3**) with speed nuts **138** (FIG. **3**) screwed onto compression threads **144** (FIGS. **5** and **6**), which are obscured in FIG. **4**. Like FIGS. **1-3**, FIG. **4** shows fixation bolt **110**, outer sleeve **108** (inner sleeve **106** is obscured in shortened position **102**), swivel hinges **112**, stationary end **114**, moving end **116**, jam nut **120** and C/D nut **122**.

FIG. **5** is an illustration of lockable swivel hinge **112**, first introduced in FIG. **1**, in greater detail. Hinge **112** includes a body **142** with a threaded portion, or compression threads, **144**. Compression threads **144** is used to attach hinge **112** to an orthopedic plate (see **136**, FIGS. **3** and **4** and **212**, **216**, FIG. **7**). Compression threads **144** pass through a hole (not shown) in an orthopedic plate, which is then secured with a speed nut (**138**, FIGS. **3** and **4**). In addition to securing strut **100** to the orthopedic plate, speed nut **138** presses a locking collar **146** against a swivel pin **148**, thereby locking swivel pin **148** and body **142** within a one hundred eighty degree (180°) arc with respect to compression either leadscrew **118** (FIGS. **1-3**) or outer sleeve **108** (FIGS. **1-4**). In addition, body **142** may be rotated with respect to orthopedic plates **136** and locked in any position, i.e., body **142** is rotatable orthogonally three hundred sixty degrees (360°) with respect to orthopedic plates **136** by virtue of the fact that, on stationary end **114** (FIGS. **1-3**), outer sleeve **108** may be rotated and, on moving end **116** (FIGS. **1-3**), leadscrew **118** may be rotated.

A locking, or dowel, pin **150** is inserted through swivel pin **148** so that either leadscrew **118** (FIG. **1-3**) or outer sleeve **108** (FIGS. **1-3**) is securely attached to a respective lockable swivel hinge **112**. A channel **152** in body **142** provides space for either leadscrew **118** or outer sleeve **108** to be inserted into moving end **116** (FIGS. **1-3**) or fixed end **114** (FIGS. **1-3**), respectively, to be mounted and enables swivel hinge **112** be positioned within a one hundred eighty degree (180°) arc. A parallel pair of surfaces **154**, one of which is obscured by the orientation of lockable swivel pin **112**, provide a means to place a wrench (not shown) while tightening locking collar **146** against swivel pin **148** with speed nut **138**.

FIG. **6** is an illustration of the lockable swivel hinge **112** of FIGS. **1-5** disassembled to more clearly show component parts. Included are body **142**, compression threads **144**, locking collar **146**, swivel pin **148**, lock pin **150**, channel **152** and parallel surfaces **154**, all of which were introduced in FIG. **5**. At stationary end **114** (FIGS. **1-4**) of strut **100** (FIGS. **1-4**), a portion (not shown) of outer sleeve **108** (FIGS. **1** & **2**) extends into channel **152**. Swivel pin **148** extends through a hole **156** of body **142** and the extended portion of outer sleeve **108** passes through a hole **158** in swivel pin **148**. The extended portion of outer sleeve **108** is then locked into place by press fitting pin **150** through the center of swivel pin **148** and through a hole (not shown) in the extended portion of outer sleeve **108**.

In a similar fashion, swivel hinge **112** is attached to leadscrew **118** (FIGS. **1-4**) at moving end **116** (FIGS. **1-4**). Leadscrew **118** extends into channel **152**. Swivel pin **148** is inserted into hole **156** of body **142** and leadscrew **118** passes through hole **158** in swivel pin **148**. Leadscrew **118** is then locked into place by press fitting pin **150** through the center of swivel pin **148** and through a hole (not shown) in leadscrew **118**.

FIG. 7 is an illustration of an illustration of an External Bone Fixation (EBF) device **200**, attached to a patient's leg bone **202**, heal bone **204** and foot bone **206**, that employs telescoping, adjustable strut **100** shown in FIGS. **1** and **2** and the lockable swivel hinge **112** shown in FIGS. **1-4**. EBF device **200** includes a number of frame elements, such as a frame elements **210**, **212**, **214** and **216**.

FIG. 7 shows three of four telescoping, adjustable struts **100** with the fourth being obscured by bones **202**, **204** and **206**. In this example, struts **100** attach to frame elements **212** and **216** although that may also be employed to attach to other frame elements, both those illustrated and ones not illustrated but familiar to persons skilled in the relevant arts as well.

EBF device **200** is attached to leg bone **202** with two (2) pins, a pin **220** and a pin **222**. Pins **220** and **222** are attached to EBF device **200** with fixation bolts **224** and **226** on frame elements **210** and **214**, respectively. EBF device **200** is also attached to leg bone **202** with an orthopedic wire **228**, attached by means of a fixation bolt **230** on frame element **212**. Although not clearly visible in FIG. **4**, in this example, wire **228** passes through leg bone **202** and is also attached to EBF device **200** at a second point with a fixation bolt (not shown) on the opposite of side of leg bone **202** than fixation bolt **230**. In a similar fashion, orthopedic wires **232** and **234** attach frame element **216** of EBF device **200** to ankle bone **204** and foot bone **206**, respectively. By adjusting the length of struts **100**, as described above in conjunction with FIGS. **1-4**, and the orientation of swivel hinges **112**, the positions of orthopedic plates such as plates **212** and **216** can be customized for a specific patient and treatment.

While the claimed subject matter has been shown and described with reference to particular embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and detail may be made therein without departing from the spirit and scope of the claimed subject matter, including but not limited to additional, less or modified elements.

We claim:

1. A telescoping, adjustable orthopedic strut for use in conjunction with an external bone fixation (EBF) device, comprising:

a plurality of swivel hinges, each swivel hinge comprising:  
 a body;  
 a channel within the body;  
 a threaded portion coupled to the body;  
 a locking collar, wherein the locking collar is placed over the threaded portion; and  
 a speed nut;

wherein each swivel hinge is lockable in any position within a one hundred eighty degree (180°) plane within the channel and a three hundred sixty degree (360°) angle of rotation with respect to an orthopedic plate of the EBF device;

an outer sleeve; comprising:  
 a groove extending through the outer sleeve; and  
 a compression/distraction (C/D) nut attached to a first end of the outer sleeve and configured to rotate three hundred and sixty degrees (360°) with respect to the outer sleeve;

wherein a first swivel hinge of the plurality of swivel hinges is coupled to a second end of the outer sleeve, the second end opposite the first end;

an inner sleeve configured to slide within the outer sleeve;  
 a fixation bolt that passes through the groove and threads into the inner sleeve such that, when the fixation bolt is

loosened, the inner sleeve and outer sleeve may be positioned with respect to each other and, when the fixation bolt is tightened, the inner sleeve and outer sleeve are secured with respect to each other thereby providing an acute adjustment to an overall length of the strut;

a leadscrew threaded through the C/D nut such that a first portion of the leadscrew extends into the inner sleeve and a second portion of the leadscrew is positioned outside the inner sleeve;

a jam nut threaded onto the leadscrew such that the leadscrew is fixed into position with respect to the C/D nut when the jam nut is tighten against the C/D nut and the leadscrew is free to rotate with respect to the C/D nut when the jam nut is not tightened against the C/D nut, thereby providing a fine adjustment to an overall length of the strut; and

a second swivel hinge of the plurality of swivel hinges coupled to an end of the lead screw corresponding to the second portion.

2. The telescoping, adjustable orthopedic strut of claim 1, each swivel hinge further comprising a swivel pin, wherein the swivel pin attaches the body to a corresponding outer sleeve or leadscrew.

3. The telescoping, adjustable orthopedic strut of claim 2, each swivel hinge further comprising a lock pin, wherein the lock pin secures the swivel pin to the body and the corresponding outer sleeve or leadscrew.

4. The telescoping, adjustable orthopedic strut of claim 2, wherein the speed nut, when tightened against an orthopedic frame element, presses the locking collar against the swivel pin to fix the swivel pin into both a particular angle of the one hundred eighty degree (180°) plane and a particular angle of the three hundred and sixty degrees (360°) of rotation.

5. The telescoping, adjustable orthopedic strut of claim 1, further comprising a clamping washer, wherein the fixation bolt passes through the clamping washer and the outer sleeve and, wherein when the fixation bolt is tightened, the clamping washer is compressed between the fixation bolt and the outer sleeve.

6. An external bone fixation (EBF) device, comprising  
 a plurality of at least two orthopedic plates; and  
 a plurality of at least two telescoping, adjustable orthopedic struts coupling two of the plurality of orthopedic plates, each strut comprising:

a plurality of swivel hinges, each swivel hinge comprising:  
 a body;  
 a channel within the body;  
 a threaded portion coupled to the body;  
 a locking collar, wherein the locking collar is placed over the threaded portion; and  
 a speed nut;

wherein each swivel hinge is lockable in any position within a one hundred eighty degree (180°) plane within the channel and a three hundred sixty degree (360°) angle of rotation with respect to a corresponding orthopedic plate of the two orthopedic plates;

an outer sleeve; comprising:  
 a groove extending through the outer sleeve; and  
 a compression/distraction (C/D) nut attached to a first end of the outer sleeve and configured to rotate three hundred and sixty degrees (360°) with respect to the outer sleeve;

wherein a first swivel hinge of the plurality of swivel hinges is coupled to a second end of the outer sleeve, the second end opposite the first end; an inner sleeve configured to slide within the outer sleeve; 5  
 a fixation bolt that passes through the groove and threads into the inner sleeve such that, when the fixation bolt is loosened, the inner sleeve and outer sleeve may be positioned with respect to each other and, when the fixation bolt is tightened, the inner sleeve and outer sleeve are secured with respect to each other thereby providing an acute adjustment to an overall length of the strut; 10  
 a leadscrew threaded through the C/D nut such that a first portion of the leadscrew extends into the inner sleeve and a second portion of the leadscrew is positioned outside the inner sleeve; 15  
 a jam nut threaded onto the leadscrew such that the leadscrew is fixed into position with respect to the C/D nut when the jam nut is tighten against the C/D nut and the leadscrew is free to rotate with respect to the C/D nut when the jam nut is not tightened against the C/D nut, thereby providing a fine adjustment to an overall length of the strut; and 20  
 a second swivel hinge of the plurality of swivel hinges coupled to an end of the lead screw corresponding to the second portion. 25

7. The external bone fixation (EBF) device of claim 6, each swivel hinge further comprising a swivel pin, wherein the swivel pin attaches the body to a corresponding outer sleeve or leadscrew. 30

8. The external bone fixation (EBF) device of claim 7, each swivel hinge further comprising a lock pin, wherein the lock pin secures the swivel pin to the body and the corresponding outer sleeve or leadscrew. 35

9. The external bone fixation (EBF) device of claim 7, wherein the speed nut, when tightened against a corresponding orthopedic plate, presses the locking collar against the swivel pin to fix the swivel pin into both a particular angle of the one hundred eighty degree (180°) plane and a particular angle of the three hundred and sixty degrees (360°) of rotation. 40

10. The external bone fixation (EBF) device of claim 6, further comprising a clamping washer, wherein the fixation bolt passes through the clamping washer and the outer sleeve and, wherein when the fixation bolt is tightened, the clamping washer is compressed between the fixation bolt and the outer sleeve. 45

11. A telescoping, adjustable orthopedic strut for use in conjunction with an external bone fixation (EBF) device, comprising: 50  
 a plurality of swivel hinges, each swivel hinge comprising:

a body;  
 a channel within the body;  
 a threaded portion coupled to the body;  
 a locking collar, wherein the locking collar is placed over the threaded portion;  
 a swivel pin;  
 a lock pin; and  
 a speed nut;  
 wherein each swivel hinge is lockable in any position within a one hundred eighty degree (180°) plane within the channel and a three hundred sixty degree (360°) angle of rotation with respect to an orthopedic plate of the EBF device; and  
 wherein the speed nut, when tightened against a corresponding orthopedic plate of the EBF device, presses the locking collar against the swivel pin to fix the swivel pin into both a particular angle of the one hundred eighty degree (180°) plane and a particular angle of the three hundred and sixty degrees (360°) of rotation;  
 an outer sleeve; comprising:  
 a groove extending through the outer sleeve; and  
 a compression/distraction (C/D) nut attached to a first end of the outer sleeve and configured to rotate three hundred and sixty degrees (360°) with respect to the outer sleeve;  
 wherein a first swivel hinge of the plurality of swivel hinges is coupled to a second end of the outer sleeve, the second end opposite the first end;  
 an inner sleeve configured to slide within the outer sleeve;  
 a fixation bolt that passes through the groove and threads into the inner sleeve such that, when the fixation bolt is loosened, the inner sleeve and outer sleeve may be positioned with respect to each other and, when the fixation bolt is tightened, the inner sleeve and outer sleeve are secured with respect to each other thereby providing an acute adjustment to an overall length of the strut;  
 a leadscrew threaded through the C/D nut such that a first portion of the leadscrew extends into the inner sleeve and a second portion of the leadscrew is positioned outside the inner sleeve;  
 a jam nut threaded onto the leadscrew such that the leadscrew is fixed into position with respect to the C/D nut when the jam nut is tighten against the C/D nut and the leadscrew is free to rotate with respect to the C/D nut when the jam nut is not tightened against the C/D nut, thereby providing a fine adjustment to an overall length of the strut; and  
 a second swivel hinge of the plurality of swivel hinges coupled to an end of the lead screw corresponding to the second portion.

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